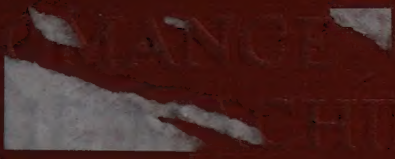

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ROMANCE OF THE MACHINE

ROMANCE OF THE MACHINE

BY

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OF COLUMBIA UNIVERSITY

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ROMANCE OF THE MACHINE

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I

ROMANCE OF THE MACHINE

"MACHINE CIVILIZATION" is a favorite topic of several noted European writers. They have nothing good to say for it. Some of them write of it as an American plague, which is invading Europe and threatening to undermine its ancient culture. "Americanism" is the name which these writers frequently give to this new civilization, and Americanism, in their opinion, is sordid materialism. This is indeed a severe indictment of the ideals of our democracy. But are these European critics qualified to interpret American life and its ideals? Is their indictment supported by evi-

dence from American history, or by evidence against American science and engineering, which they hold responsible for the evils of the so-called Machine Civilization?

Every thoughtful student of American history knows that Washington, Franklin, Jefferson, and the other fathers of this country were idealists of the highest type. History has no greater idealist than Lincoln, the leader of American idealists in a struggle for a noble cause. Is it possible that these American idealists have founded a nation of sordid materialism? The history of America to the close of the Civil War answers this question with an emphatic "No!" What calamity, then, has happened since the days of Lincoln to drag this nation into the mire of materialism?

One of the most memorable events in the history of America since the

Civil War is the well-known movement for higher intellectual endeavor. It started in 1863, when, with the sanction and support of Lincoln, the National Academy of Sciences was founded. Joseph Henry, Frederick Barnard, William Draper, Andrew White, Daniel Gilman, and several other idealists of the Academy were its spiritual leaders. Johns Hopkins University, founded in 1876, is its earliest visible record. The programme of the founders of this university was brimful of idealism; it is to-day the programme of all American universities. The universities are the guardians of idealism in all our higher intellectual endeavors. The idealism of science fostered in the research laboratories of the American universities has gradually been transplanted to the research laboratories of our industries. Our industrial leaders

were quick to discover that the cultivation of scientific idealism in our universities and in the industrial research laboratories was the most effective means of advancing the creative power of American industries. They gave hearty support to the idealist in the research laboratories of our universities. This idealist retained his independence, but he blazoned the path which the industrialist followed. The leadership of scientific activity has remained in our universities throughout this period of the organization of our higher intellectual endeavors. These universities are responsible if during this period American civilization has become a mere machine civilization drifting away from the ideals of the fathers of the country, of Lincoln, and of the other idealists who inaugurated our movement for higher intellectual endeavors. But the respon-

sibility of the universities rests upon the shoulders of their disciples, the scientists and the engineers. They have preached and practised what they have believed to be the doctrine of scientific idealism. Has their doctrine misled this nation into the mire of sordid materialism? "It has," say the European critics of our civilization, "because it has created the worship of a heathen idol—the 'machine.'" These critics take no pains to prevent the inference that the materialism of the machine is the most important offspring of our national movement for higher intellectual endeavors. If their contention is true, then our boasted movement for higher intellectual endeavors has produced a result diametrically opposite to that sought by its spiritual leaders—the dream of Joseph Henry, of Barnard, and of other American idealists of a half century

ago has vanished into thin air; their ideals have been dispelled by the everlasting clatter of the American machine, the alleged idol of American science and engineering.

American scientists and engineers deny that these European critics of our civilization are qualified to interpret the real meaning of the American machine or of any other machine. These critics display to the disciplined eye of the American engineer a woefully scanty scientific training; their ideas about the mission of machines in the shaping of terrestrial life, and in the guidance of the destiny of man, are vague, to say the least. Perhaps they would have a different story to tell if they knew a little more of the scientific side of the subject which they delight in discussing without the slightest hesitation or reserve. A study of the origin of the "machine" may, I

hope, help to persuade these critics to reconsider their sweeping condemnation of the civilization which America has created with the machine's aid. I venture now to give them a brief story of the machine. The story of the primordial machines which nature constructed and has employed since the first dawn of life on this terrestrial globe must be told first. These are the primordial structures the operations of which suggested to the inventive genius of man the use of machines as developed by modern science and engineering.

THE COSMIC ENGINE

The most significant physical fact in the life of our planet is its motion through the vast energy stream of solar radiation. From this stream it inhales its breath of life. The sun-worship of the ancients testifies that

long before science began to guide human experience man had recognized the existence of this relationship between solar radiation and terrestrial life. But in the sun-worship of ancient Asia and Greece man expressed his belief that herbs and fruits, the food for man and beast, were the only blessings which solar radiation brought to terrestrial life. Modern science has revealed that there are other blessings which solar radiation has stored up and is storing up for the benefit of man. Among these blessings are the stores of energy in wood, coal, and oil. We know to-day that this energy was destined to mould the structure of human civilization.

But energy and its power are modern concepts, whose full meaning became known when modern science had penetrated more deeply into the physical activities which guide the

course of human history. This science revealed that the trustiest servant in these activities is the available energy which solar radiation has provided in the vast storehouses of our globe. The steam-engine, invented a little over one hundred and fifty years ago, supplied the earliest illustration of this new knowledge, the foundation of our modern industrial progress, and of the civilization which this progress has created.

It is difficult to form a comprehensive view of our modern civilization without some knowledge of the modern science of energetics. This science reveals a view of the physical universe which was unknown even as recently as two centuries ago. It is a universe of vast energy streams of stellar radiation fed by the energy sources of the luminous stars, including our central star, the sun. These energy

streams fill every nook and corner of the universe with radiant energy, some of which will some day and somewhere become the breath of life of organic structures. There is no idle vacuum anywhere in the universe so long as these stellar energy sources are in action; but should they dry up, their radiation streams of energy would dry up, and the physical universe would be as dead as the deadest grave of ancient Egypt. The countless stars then would be just so many graves in the lifeless cosmic vacuum. Stellar radiation is the visible evidence of a living universe.

With this view of the universe one cannot fail to recognize that the energy stream of solar radiation is the primary source of physical power in the evolution of terrestrial life. This thought is forcibly impressed upon us when we contemplate the most strik-

ing features of the face of our mother earth. They are the lofty levels of the continents towering high above the ocean levels; the garb of vivid green which clothes the hillsides and valleys filled with the joys of organic life; the all-enveloping ocean of the terrestrial atmosphere. These terrestrial features exhibit a structure which, as if designed by a power engineer, is splendidly adapted for the work of harnessing the energy of solar radiation. A part of this energy is absorbed by the terrestrial atmosphere, and supplies the driving power which propels the trains of clouds loaded with the products of solar action upon the terrestrial waters. This precious load of water vapor lifted on high by solar radiation and driven by the atmospheric currents to the lofty continental levels, ultimately yields to the gravitational force. It descends upon

the earth, and starts the missionary journey which carries its life-sustaining fluid to the thirsty hillsides and valleys. The scientific mind cannot fail to see in this cosmic operation the action of a cosmic engine which derives its driving power from the fires of our central star, the sun. The suggestion that a prosy machine, fed by the fires of the solar furnace, forms the foundation of the creative processes of our mother earth will perhaps shock the sensibilities of an æsthetic soul. Such a soul delights in the poetic fancy of the ancients, who saw in our central star a radiant sun-god bestowing upon terrestrial life the gifts of his benevolence. Not less shocking to some æsthetic souls is the story of science which says that countless terrestrial machines constructed by nature's hand are fed by this gigantic cosmic engine and that all of them

are eternally busy in the upbuilding of life on our terrestrial globe.

Behold now the second striking feature of our mother earth, the hillsides clothed with the garb of vivid green of the flourishing forests! Each one of their countless millions of trees bristles with enormous multitudes of busy leaves inhaling the breath of activity from the life-giving energy of solar radiation. Each leaf is like a suppliant hand imploring heaven for the blessings of its radiation streams. Here we are witnessing one of the most important of the fundamental physical processes in the evolution of organic life on our mother earth. Each leaf with its green chlorophyl is kept busy by the stimulating action of the ultra-violet light of solar radiation; absorbing the molecules of carbon dioxide of the atmosphere; breaking these molecules up into carbon

and oxygen; retaining the carbon and releasing the oxygen. This is the carbon which the tree needs for its bodily structure, and this is the oxygen which replenishes the power of our atmosphere to sustain animal life. No other physical process is more important in the evolution of terrestrial life than this separation of oxygen from carbon in the molecules of our atmosphere. In no other terrestrial process do we see in action so vast a number of machines employed in a mass production in comparison with which the mass production of human mortals is a vanishingly small affair. The physical activity of our "Machine Civilization" is a tiny and crude copy, only, of the activity of nature's primordial machines.

When the word "machine" is used in this connection it is not used as a mere figure of speech. The bodily

structure of a tree is a machine, because it provides for the life processes of the tree suitable channels, just as the steel structure of the steam-engine provides for the flow of steam suitable channels in which by its pressure and expansion it can do useful work. But the bodily structure of the tree is a self-made and self-repairing machine. The life processes in its channels perform two different kinds of useful work. One product of its work is the fruit of the tree, food for man and beast; the other product is the carbon stored up in the body of the tree. This carbon represents a definite amount of solar energy which can be obtained by burning up the wood, that is by reuniting the carbon in the body of the tree with the oxygen of the atmosphere from which it had been divorced by the action of the chlorophyl when the tree was formed.

Who can look at the genial flame of his fireplace without seeing in the burning log a new life rising as if by a resurrection from the organic life which the axe of the woodman had terminated long ago? This second life of the tree is short and sweet; it is a rejoicing of the carbon molecules in the reunion with their loving partners, the oxygen molecules of the atmosphere. When this brief rejoicing is over the energy stored up in the body of the tree is gone, and nothing remains but a few handfuls of ashes. They remind us of the self-made machine which served a useful purpose not only when it provided the life processes of a tree with suitable channels, but also after it was scrapped by the blows of the woodman's axe. Here is a machine which has two beautiful lives. During its first life it adorned the face of our mother earth, and sup-

plied sweetness to the nurture of man and beast; during its second life it carried to our fireside the beauties and comforts of its genial flame. Here is a machine which is a thing of beauty and a joy forever; it should remove the taint of materialism which some people attach to the word "machine."

A similar story can be told of every herb and of every blade of grass and of every animal on earth; their material bodies are machines which provide suitable channels for the physical processes of life. A by-product of these processes is the increase of available terrestrial energy like that stored up in the carbon of a tree. A practically infinite number of these terrestrial machines, constructed by the patient and experienced hand of nature, is eternally busy giving comfort and joy to the present generation and storing up available energy for the

comfort and joy of future generations. A vast deposit of energy thus stored up was hidden during millions of years in the bosom of mother earth. To-day these deposits are precious treasures of man; they aid him in his efforts to make human life worth living.

Coal and oil are the earthly remains of scrapped machines constructed by the hand of nature many æons ago, and employed for aiding the life processes in the vegetable and animal kingdoms of our globe. The scrapping was not the work of the human hand, like that of the woodman and his axe; it was the work of terrestrial cataclysms which buried the bodies of prehistoric animals of the sea and land, and of terrestrial forests. Their graves were hidden in the deep recesses of the earth. Water and air were not admitted into these guarded graves, to in-

dulge there their action of wasteful decay. The buried bodies rested in a peace incomparably longer than that of Tutankhamen in his royal grave. Delivered from their graves, they live again when the carbon of their molecules joins in happy wedlock with their former partners, the oxygen molecules, from which they were separated long before Adam began to pass his days of blissful idleness in the garden of Eden. The excavations which discovered those ancient graves of prehistoric organic structures, transformed into coal and oil, were more precious to laboring humanity than the excavations of ancient Egypt, Syria, Arabia, and Greece. These latter have revealed to man the glories of past civilizations, and they have an inestimable value. But the excavations which have brought to the terrestrial surface the carbon stored up in the

scrapped machines which many æons ago were storing up available energy for a future civilization have even a greater value for the destiny of mankind. Their existence is a prophecy of what this future civilization promises. We have every reason to hope that it will be more glorious than any civilization which the world has ever seen. The countless primordial machines of nature energized by our central star ever since terrestrial life began would have accomplished nothing if they had not taught man how to employ their methods of operation and their products of available energy for the accomplishment of greater achievements than any which were possible without such methods. But they have taught him, and man has taken his lessons from nature ever since the light of reason became the guiding light of his life. One of the earliest

evidences of these lessons is in Job's epic:

"But ask the beasts, and they shall teach thee; and the fowls of the air, and they shall teach thee."

"Or speak to the earth, and it shall teach thee; and the fish of the sea shall declare unto thee."

Job knew that the language of nature is an inexhaustible source of understanding; that man must learn it, and that to those who know its meaning it will reveal counsel and understanding.

MACHINES INVENTED BY MAN

An open-minded and unprejudiced interpretation of the language of nature is the primary object of science. It leads to an understanding which gives us glimpses of the eternal truth, and truth makes us free. This freedom is a deliverance not only from

the burdens of ignorance, but also from the burdens of physical labor to which man was condemned when God said to Adam:

"In the sweat of thy face shalt thou eat bread, till thou return unto the ground."

As soon as man understood the language of nature, addressed to him by her operations of the cosmic engine, he began to evolve the structure of the steam-engine. In this invention we see a glimpse of the eternal truth which enabled man to free himself not only from the errors of the belief in a *perpetuum mobile*, but also from some of the hardships of physical labors. The inventor planted the seed of hope in the soul of man that some day he would work out his salvation from the burdens of Adam's original sin; that hope is stronger to-day than ever before.

The invention of the steam-engine gave man a crude copy only of the cosmic engine. The mind of man, and his awkward hand, can never do more than make a crude copy of nature's subtle ways. The energy of the flame under the boiler of the engine is a morsel of the solar energy stored up in the carbon of nature's scrapped machines —wood, coal, and oil. The flame is a tiny terrestrial offspring of the solar flame of the cosmic engine. The duty assigned to it by the inventor is the same as that of the solar energy stream when it lifts on high the water vapors of the terrestrial oceans. Expansions and condensations perform similar functions in one as in the other. The comparison could be carried farther for the purpose of pointing out in greater detail the resemblance between the engine invented by man and its cosmic prototype. But enough has

been said to trace the steam-engine and its operations to their celestial origin, the cosmic engine. Remember that and you will speak with reverence of the heaven-born steam-engine and its operations.

The steam-engine is the earliest source of the man-invented power which propels the material progress of our modern civilization. Let us stop for a moment and glance at the speed of this progress. In the beginning of the nineteenth century there were barely half a dozen steam-engines in the United States; to-day there are hundreds of thousands. The gas-engine, the offspring of the steam-engine, was born less than seventy years ago, but already there are over twenty millions of them carrying comfort and joy to the American home. The steam-engine and its offspring, the gas-engine, have called into ex-

istence other machines to aid them in supplying the moving power to our civilization.

The mission of the cosmic engine is to supply energy to the life processes in the animal and vegetable kingdoms; similarly the mission of the steam-engine, and of its progeny, the gas-engine, is to supply the power of action to countless other machines invented by man for the purpose of guiding the progress of human society. Among these creations of man's inventive genius the electrical machines occupy a place of honor. These machines, like those which supply them with the power of action, are also of celestial origin. The observing eye of Franklin deciphered the message of nature's thundering voice whenever the dazzling lightning pierced its fiery path from cloud to cloud, or from cloud to earth. The deciphered

message disclosed to him the secret of the irresistible power of moving electricity. The disclosure of this secret guided the genius of man to the invention of the electrical machines, the offspring of the heavenly lightning. Moving matter and moving electricity were thus harnessed into the service of man. The harness in each case is a machine which has its origin in the heavens above. Each is a gift from heaven presented to man as a reward for his diligent study of the language of nature. Moving matter in the steam-engine and in its offspring, the gas-engine, and moving electricity in the electrical machines, supply the propelling force to our modern civilization. The energy of their motion feeds upon the energy morsels which solar radiation brought from heaven to earth, and which the earth stored up as coal and oil in the guarded

depths of her bosom. These stored-up treasures waited millions of years until nature's lessons taught man how to use them. It is unthinkable that man, aided by these heaven-born machines, and by the celestial energy which drives them, and guided by the hand of loving nature, should use all these heavenly gifts for the purpose of creating a civilization which will fill the soul of mankind with sordid materialism. Even the blackest pessimist should revolt against so gloomy a picture of modern progress.

Modern civilization is called Machine Civilization, because the name connotes its most obvious physical characteristics. The name was invented and it is used always by writers who have an ill-concealed contempt for the "machine" and for the civilization which it has produced. Machine civilization has, it is true,

reached its highest development in this country, and we are, therefore, accused of sordid materialism, of a worship of the machine. It is the worship of a heathen idol, our European critics tell us, and they hold our scientists and engineers responsible for the spread of this heathen worship.

Let us assume that this worship exists, but why is it a worship of heathen idols? Look at the pious peasant, kneeling by the roadside to pray before the wooden image of Christ crucified. It is not the wood and the paint of the image, but the spirit of Christ, which he worships—the spirit which brings him closer to God and assures him that he is the child of a loving creator. It is not the material machine and its material service, but the spirit behind them, which the scientists and the engineers worship. This spirit has brought them closer to the

bosom of mother nature whence it was revealed; a revelation which assures them that nature loves them and will guide them in their efforts to contribute to the evolution of a higher civilization, if they will but learn to understand her language. The machine is the visible evidence of the close union between man and the spirit of the eternal truth which guides the subtle hand of nature.

This is the spirit which inspired Galileo, Newton, Faraday, and other patient students of the language of nature. They laid the foundation of the machine civilization, to the superstructure of which this country has contributed so much. "Yes," say our European critics, "you have contributed much to the superstructure, but what contributions have you made to its foundation? You make the machine, but you make no discoveries in

abstract science; the useful attracts you, the abstract has no charm for your utilitarian mind." The answer to this charge is obvious. Franklin made a great discovery when his kite brought the lightning to earth and showed us that lightning is a motion of electricity carrying with it an irresistible power. Franklin had a practical mind, but he never hesitated to turn his thoughts to abstract problems of science. Benjamin Thompson, a practical Yankee engineer, was the first to show by experiment that heat is a form of energy obtainable from other forms of energy. The method suggested by his experiments was employed in the first demonstration that a given quantity of heat corresponds to a definite quantity of mechanical work. Thompson's practical turn of mind did not prevent him from thinking effectively about one of the most

abstract scientific problems of his time. Joseph Henry, the inventor of the electromagnetic telegraph, discovered the momentum of moving electricity, a discovery which taught the world how to make an induction coil, thus aiding the physicists of our generation in such epoch-making discoveries as those of electrical waves and X-rays. William Draper's discoveries contributed a lion's share to the science of radiation when, eighty years ago, this great science was still in its infancy. Josiah Willard Gibbs of Yale discovered a new science, the science of Physical Chemistry. He is often called the Newton of this science. It was the solution of so abstract and novel a problem in science that not even Gibbs's most learned colleagues at Yale of fifty years ago understood its full meaning; the learned German professors needed over fifteen years to

discover its great importance. There was not a single utilitarian thought in this historic essay entitled "The Equilibrium of Heterogeneous Substances." To-day it is the foundation of one of the most beautiful among modern sciences; it has revolutionized chemical philosophy. Michelson, a graduate of the U. S. Naval Academy at Annapolis, and an engineer by training, gave to the world the first accurate determination of the velocity of light. He also demonstrated that this velocity does not change with respect to the observer when both the observer and the source of light are moving together through space. These experimental achievements certainly dealt with one of the most abstract problems in science. They were the foundation upon which Einstein's philosophy built the wonderful structure of Relativity. This list of American

discoverers could be considerably extended; it covers a part of the physical sciences only and does not include the American achievements in abstract sciences during the last forty years. But the above list of contributors alone should convince even the most pessimistic critic that America has contributed a very creditable share to the world of abstract science. It might have perhaps contributed even more, if it had devoted more attention to problems of abstract science and less to concrete problems the solution of which leads to the birth of a new machine. But the rapid growth of the United States demanded this; it needed sorely the aid of machines.

II

WASHINGTON'S AND LINCOLN'S ADMIRATION OF THE MACHINE

A MERE glance at American history from the days of the American Revolution to the end of the Civil War shows why during this period the machine was so sorely needed in the making of the American nation. Parts of this history, relating to the lives of Washington and Lincoln, will furnish the simplest illustration of this well-known historical fact.

As soon as the American Revolution had been won and the peace of 1783 signed, the enthusiasm which had kept the colonies in a solid unit began to cool off. Nobody observed this more keenly and with more anxiety than Washington himself. The framing of the Constitution by the

Constitutional Convention, over which he presided, gave him many opportunities to study the centrifugal forces in the thirteen States. The Constitution was intended to strengthen the bond of union between them, and to eliminate the centrifugal tendencies possible under the Articles of Confederation. When Washington presented to Congress the draft of the Constitution, he uttered the following memorable words:

"In all our deliberations on this subject we kept steadily in view that which appeared to us the greatest interest of every true American, the consolidation of the Union in which is involved our prosperity, felicity, safety, perhaps our national existence."

Consolidation of the Union was the uppermost thought in every true American mind for many years after

Washington's utterance of these memorable words. It is still there to-day. The adoption of the Constitution had removed the danger from centrifugal forces which always was present under the Articles of Confederation. But Washington, an engineer by his earliest training, still felt that there was crying need for a powerful centripetal force which even the Constitution failed to provide. A waterway between the Atlantic and the trans-Appalachian and trans-Alleghany regions of the united colonies was his favorite project for creating this force. He often expressed his fear that the trade routes to the Mississippi and to the Lakes might create a split between the western part of the original thirteen States and the eastern parts. Washington's project was not fully realized during his lifetime, but it always was favored by the American patriots who were striving

to consolidate the Union by creating economic bonds between the various States.

The necessity of consolidating the Union by economic bonds became more urgent and presented a most complex problem when, after the acquisitions of Florida, Louisiana, New Mexico, Texas, and California, the United States had extended its domain over its present vast territory between the Atlantic and the Pacific. To-day we know that it was partially solved by the construction of roads and railroads, and by the improvement of old waterways and the digging of new waterways. These were gigantic tasks, and could not have been performed without the magic of the machine. Jim, the humble fireman, who gave me my first lessons in boiler-room management, must have thought of this magic when he told me, over

fifty years ago: "The English made us write the Declaration of Independence, and they gave us the steam-engine with which we made our independence good."* If the European critics of our machine civilization would look at American history from Jim's point of view, they would then, perhaps, take more kindly to this civilization.

Jim's way of judging the events of early American history always reminded me of an interesting incident in Washington's life. There is a record in his diary which shows that he was thrilled by Rumsey's invention of a boat which he saw moved against the current by the action of that current. It gave him a new hope for the development of his favorite project, the waterways. Rumsey's crude invention probably thrilled him more

*"From Immigrant to Inventor," p. 75.

than did Franklin's great discovery of the irresistible power of moving electricity and of the new truth which this discovery revealed. Rumsey's scheme was directly connected with a national problem which Washington was revolving in his mind. Franklin's discovery was not. The pioneering days of America were much more interested in the birth of a new machine than in discoveries of abstract science.

Lincoln was so impressed by the achievements of the machines of his day that he sought diversion from his study and practice of law by extensive reading of books on science. Consolidation of the Union by improved interstate communications, the favorite thought of Washington, was also the favorite thought of Lincoln. In one of his earliest political canvasses he made the following declaration of principles:

"Whether elected or not, I go for distributing the proceeds of the sales of public lands to the several States, to enable our State, in common with others, to dig canals and construct railroads.

A most characteristic declaration of a youth of twenty-seven, who had learned the art of piloting boats and ferries on the Sangamon, Ohio, and Mississippi Rivers! Lincoln's biographers, Nicolay and Hay, make the following significant comment upon this declaration of principles:

"This was good Whig doctrine at that time, and the young politician did not fancy he could go wrong in following in such a matter the lead of his idol, Henry Clay."

Clay and Webster were the two most eloquent apostles of Washington's gospel of consolidation of the American Union; Lincoln was their ardent disciple.

Washington saw in the machine a promise of a powerful aid to consolidation in its encouragement of the opening of waterways between the States. Lincoln saw this promise more than fulfilled as he watched the busy locomotives pulling train-loads of precious freight from coast to coast, and steamboats ploughing their way along navigable waters. To these two great idealists neither the machine nor its operation suggested materialism. The machine served what Washington called "the greatest interest of every true American, the consolidation of the Union in which is involved our prosperity, felicity, safety, perhaps our national existence." To him, and later to Lincoln, this was an exalted service. Even to-day we appraise the importance of an epoch-making machine in terms of its service to the consolidation of our Union.

It is a significant historical fact that the two greatest idealists in American history, Washington and Lincoln, were humble surveyors in the days of their early manhood. Their lives testify that the handling of tools or machines does not disturb the idealism which sits enthroned in the soul of man. Lincoln, the sturdy young pilot of a steamboat on the Sangamon River, the hired deck-hand on a Mississippi flatboat, the clever inventor of a machine for lifting stranded flatboats, was moved to tears by the sight of the slave market at New Orleans. His hand was the horny hand of a rail-splitter, but his heart was as tender as that of a Sister of Mercy, and his soul radiated the idealism of a saint. His practical mind, disciplined by the hardships of a pioneer's life, never conflicted with his native idealism.

Washington's and Lincoln's ap-

praisals of the consolidating power of the machine found an enthusiastic response in the hearts of the American people of their periods. With the aid of machines they raised the huge framework of the present physical structure of the United States and stabilized it by economic riveting of its parts, the States. The machines supplied also to this framework the breath of its physical life. Eli Whitney's cotton-gin, for instance, gave to the Southern States a vigor which they had never before experienced. The people rejoiced in each new invention, because they believed that it would give impetus to the social and political progress of the country. Such was in those days the attitude of what our European critics call the practical American mind, a phrase unappreciative of the disciplining of that mind under the hardships of strenuous pio-

neering days. Why should this practical mind, disciplined by the handling of machines, interfere with the native American idealism any more than it did with Lincoln's native idealism?

The Civil War itself crowned the machine with new triumphs. One of them must be mentioned here. The *Merrimac*, the machine of the South, was playing havoc with the navy of the North; it threatened to turn the balance of the fortunes of war in favor of the South. But the *Monitor*, the machine of the North, then appeared and ended the havoc created by the machine of the South. Ericsson, the inventor of the *Monitor*, became a national idol. The flame of Lincoln's enthusiasm over the great achievements of machines in the consolidation of the Union received new fuel from the *Monitor's* triumph. Is it surprising, then, that Lincoln, one of the

greatest idealists in history, was a great admirer of the machine? Those who see nothing but materialism in the machine should remember always that Franklin, the greatest American scientist of the eighteenth century, was an intimate friend of Washington; that Joseph Henry, one of the greatest American scientists of the nineteenth century, was an intimate friend of Lincoln. Franklin and Henry were idealists and ardent lovers of abstract science, but that did not prevent their exalted friends, Washington and Lincoln, from giving unstinted admiration to applied science because of the great service of the machine in the consolidation and salvation of the Union. It seems proper to add here a passage from a book which I published seven years ago:

"The painting, 'Men of Progress,' which I first saw at Cooper Union in

1876, came back to my mind. The men represented in it, like Peter Cooper, McCormick, Goodyear, Morse, and others, did not represent the idealism in science. . . . They were practical inventors. They were the scientific idols of the American people, but they were not idealists in science. The time for idealism in American science had not yet arrived. The Union Pacific Railroad had not yet been built when the picture was painted; the western plains had not yet been compelled to yield their potential treasures of golden grain; and the vast quantities of coal and of mineral ore were waiting anxiously to be raised to the surface of the earth to serve in the development of our vast territory between the Atlantic and the Pacific. He who could aid the people in this gigantic development became the idol of the people. The names of inven-

tors, like McCormick, Goodyear, and Morse, were household words with the people of the United States, just as the names of Edison and of Bell are today. Joseph Henry, the famous scientist, was also in that historic painting, but he was in the background of it. His expression seemed to indicate that he did not feel quite at home in the group of men who were practical inventors. He was a friend of Lincoln, and his idealism in science was just as exalted as Lincoln's idealism in political philosophy. But in those days an idealist in science attracted little attention among the people of the United States, who were busily engaged in solving their numerous economic problems. Hence, Joseph Henry, the idealist in science, was practically unknown. This was the mental attitude which Europe called 'American materialism' in science. De Tocque-

ville, the famous French traveller and keen observer, said this about us in a book which he published over seventy years ago:

"It must be confessed that, among the civilized peoples of our age, there are few in which the highest sciences have made so little progress as in the United States. . . . The future will prove whether the passion for profound knowledge, so rare and so fruitful, can be born and developed so readily in democratic societies as in aristocracies. . . . The man of the North . . . does not care for science as a pleasure, and only embraces it with avidity when it leads to useful applications."*

De Tocqueville, a French aristocrat, was not a man of the north; he ignored the fact that Newton, Oersted, Faraday, Helmholtz, and Henry were men of the north. They did not embrace science because it led them to useful applications. There are no

*"From Immigrant to Inventor," p. 319.

scientists of the south who can compare with these scientific giants of the north so well as Galileo can. But Galileo did not hesitate to make useful applications of his discoveries as, for instance, the use of the pendulum for counting pulse-beats, the hydrostatic balance, the pendulum clock, and so forth. In his earliest career the Italian aristocracy admired Galileo, the ingenious inventor, and not Galileo, the great philosopher in abstract science. But his inventions did not interfere with Galileo's "passion for profound knowledge," nor with his idealism.

De Tocqueville certainly was hasty when because of the small progress of the highest sciences in the United States of those days he inferred that the American democracy probably would never provide a rich soil for the cultivation of that rare plant which he

called "passion for profound knowledge." I have already pointed out that even during the Washington and Lincoln periods American democracy had made very creditable contributions to abstract science. A comparison between the new and rapidly expanding American democracy and the old and rapidly shrinking European aristocracy was futile in the days of de Tocqueville, the aristocrat, who had small appreciation of American democracy. But the European critics of our present civilization seem to draw from him their inspiration, as though nothing had happened in the scientific activity of this country since de Tocqueville's time; our intellectual life to-day is certainly very different from that which de Tocqueville observed. The American universities did not exist eighty years ago. They were called into existence by the historic

movement for higher intellectual endeavor which started after the Civil War. Their contributions to the advancement of abstract science during the past fifty years are fully appreciated by the scientific world. The number of our Nobel Prize men in abstract science compares quite favorably with that of any other country. But our European critics insist that in our present intellectual life the machine still dominates the American mind just as much as it did in the days of de Tocqueville, the days of the early period of the American economic and political consolidation. They judge our scientific activity by what they see on its surface. There, of course, they see nothing but machines. Those who can look beneath this surface see the roots of these machines reaching deep into the rich soil of our devotion to abstract science.

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SCIENCE AND THE TECHNICAL ARTS

There are two intense scientific activities going on in this country alongside of each other to-day, as they have been going on for many years. The activity of applied science is one. It is visible in every nook and corner of our daily life. Everywhere there is some kind of a machine, a creation of applied science, which makes our life comfortable and pleasant; this is obvious to every one, and particularly to our European critics. Less obvious is the mission of applied science in the development of the more modern consolidation of the American Union. This development is just as precious a thought in the minds of every thoughtful American to-day as it was in the days of Washington and of Lincoln. Least obvious of all is another activity of our science, the ac-

tivity of abstract science, which is cultivated in the scientific research laboratories of our universities and industries. Its service is invisible to all except the experts. If the European critics of our Machine Civilization were experts in science they would certainly revise their low estimate of the American achievements in the field of abstract science during the past fifty years. The brilliant achievements of American applied science have blinded their vision; hence they fail to see our love for abstract science, or, as de Tocqueville called it, "passion for profound knowledge." They see the busy wheels of our machines, but they do not feel the spirit behind these machines, which keeps alive our "passion for profound knowledge." He who does not feel this spirit cannot understand the story which these machines are telling. Our European crit-

ics hear the loud voice of our machines, but they do not understand its language, nor the story which it is telling

THE AGE OF ELECTRICAL MACHINES

The Washington and Lincoln periods of American history advanced the consolidation of the American Union as far as the American people, guided by the spirit of Washington and Lincoln, and aided by the power of steam, could do it. But the consolidation was by no means completed. At the end of the Civil War the physical structure of the United States was still like a huge and perfectly formed embryo in which the nervous system had not yet reached its last stages of growth. This was reserved for the history of the past sixty years. In this period the machine began to play an even more important part in the physical consolidation of our Union. Progress of ab-

stract science suggested to the inventive mind new machines not dreamed of before. New machines suggested new economic bonds of union between our numerous States. The most important and novel among them were the electrical machines. One only of their many achievements will be described here.

The belief that the electrical science was in its infancy in the pioneering days of Edison and Bell is an old superstition which still persists in many untutored minds. The discoveries of Oersted, Faraday, and Henry in the first third of the nineteenth century were summed up by a Scotchman, a man of the north, James Clerk Maxwell. In an essay which he published in 1865, the year which marks the end of our Civil War, Maxwell laid the broad foundation of the electrical science. No new discovery con-

tributed to this foundation additional building-stones during the ensuing thirty years. A hypothesis, suggested by his genius, and revealed in his classical summary, was the seed from which blossomed out the electrical science of to-day. The application of this science to the solution of technical problems is the characteristic feature of that ensuing thirty-year period. Each solution gave a new machine, and hence that thirty-year period marked the beginning of the age of electrical machines.

Abstract electrical science stood practically still during that thirty-year period, but the electrical art blossomed out like a thirsty flower-bed after a shower of the early summer. The most remarkable of these machines was the telephone, invented by Alexander Graham Bell. Its first public exhibition was at the Philadelphia

Centennial Exposition of 1876—a century after the Declaration of Independence was first announced to the joyful citizens of the Quaker City by the voice of the historic Liberty Bell. No visitor to this exposition suspected that this tiny electrical machine, the telephone, would be some day a most powerful instrument in the consolidation of the American Union. The European critics of our civilization, blinded by their prejudice against American machines, do not look at it in that light even to-day.

Last October we celebrated the fiftieth anniversary of the birth of the Edison lamp. Millions of grateful Americans listened to the merited eulogy of Edison which our honored President of the United States addressed to the great inventor on that memorable anniversary day. This lent to the celebration a dignity which it

fully deserved. Four years ago was the fiftieth anniversary of the first public exhibition of the telephone. Few people knew that it was; no fitting celebration announced this historic event to the people of the United States. If a Washington or a Lincoln had been at the head of this nation in the year of our Lord 1926, the American people would have heard a magnificent eulogy of Alexander Graham Bell, and of the great service which his wonderful machine had rendered to the consolidation of the American Union. Edison's epoch-making invention was fortunate in that the semicentennial anniversary of its birth saw a man at the head of this nation who is a trained engineer and as such understands fully the service of machines in the making of America.

If, figuratively speaking, our roads and waterways and railroads are the

arteries of the American Union, then the marvellous network of our American telephone and telegraph circuits is its nervous system. Consolidation of the Union, the dream of Washington and of Lincoln, required this network for its completion just as the human body requires the network of its nervous system for its co-ordination. Twenty million telephones are in the hands of the American people to-day, and, according to a recent announcement of the American Telephone and Telegraph Company, five hundred and fifty million dollars were expended last year upon new additions to its telegraph and telephone system; one and one-half times as much as it cost us to dig the Panama Canal.

Our European critics will probably throw up their hands in holy horror when they hear that this avalanche of telephone and telegraph machinery is

descending upon this nation which, in their opinion, is already groaning under the load of machines, the pets of our machine civilization. What do they say when they hear that over twenty-five million automobiles are in the hands of the same American people, who are spending annually hundreds of millions of dollars upon concrete roads to accommodate this endless swarm of machines? They will soon inform the anxious world, if they have not already done so, that America is machine-mad, and that there is no cure for its malady, the American materialism. This, however, will not worry the American scientists and engineers; they see in this marvellous development of rapid communications the guidance of a guardian angel who has watched over the destiny of this nation from its very beginning, and guided it in its consolidation. No

longer is the physical structure of the United States an unwieldy colossus threatening to collapse under its own weight. Distance and time in its vast territory have no longer the meaning which they have in the vast territories of Russia and of China. The steam-engine, the gas-engine, and the electrical machines have produced a shrinking of both space and time in our national activity. It is no longer the slothful activity of a territorial colossus. When a New Yorker can call up his friends in Chicago, St. Louis, or even San Francisco, and get a quick response and perfectly intelligible exchange of oral communications, time and distance mean very little, incomparably less than they did prior to the Civil War. But, of course, whenever the New Yorker does that he sets into motion many machines along the connecting telephone circuits.

The æsthete who avoids employing machines, or even speaking of them, will not be thrilled by this process, which is a part of long-distance telephonic communications. He longs for the simplicity of the classical civilization, and considers the employment of a great multiplicity of machines an artificiality which makes our present civilization an artificiality, and therefore objectionable. But let him remember that an incomparably larger number of machines are set in motion whenever a message of our sensations is transmitted from a part of our body to the brain. Our organs of sight, hearing, taste, smell, and touch contain many millions of individual functional parts; the organ of sight alone has several millions of them. When the organs are busy transmitting our sensations each one of their functional units is busy contrib-

uting its share to the performance of the organ. Each one of them is a machine and works at the expense of the energy supplied by the foodstuffs, just as ordinary machines work at the expense of the energy of wood, coal, gas, and oil. We speak of feeding the fires under the boilers of our steam-engines just as we speak of feeding an organic body. This mode of speech expresses the similarity between the two processes.

One cannot mention the feeding process of an organism like our body without being reminded of the transportation system which carries the blood to the almost infinitely large number of functional units of our body. This transportation system is incomparably more complex than the whole transportation system of the United States, including the endless swarm of its twenty-five, or even more

than twenty-five, millions of automobiles. Does not this indicate that in the development of our communication and transportation systems we are imitating nature? She is our teacher, whose lessons have never led us astray. Mother nature, guided by the infinite wisdom of her Creator, does not hesitate to employ an almost endless number of machines for the purpose of constructing and operating a harmoniously co-ordinated organic body. Why should we be called materialists because we employ a multiplicity of machines for the purpose of constructing and operating a harmoniously co-ordinated physical structure of the United States? Such is its present physical structure, thanks to the wonderful service of the machines.

Consolidation of the Union, the dream of Washington and of Lincoln, is to-day a reality, much more com-

plete and beautiful than seemed possible at the time when Lincoln delivered his Gettysburg speech. History does not record so great an achievement in so short a time in the life of any other nation. But no other nation had the aid of the consolidating power of the machine at the time when it sorely needed it.

At no time in its history did this nation need so much the consolidating power of the machine as it did during the period following the Civil War. It was providential that no other period in human history was more productive of new machines than this period. That we contributed more to this productiveness than other nations shows only that the aid of the machine meant much more to our growth than it did to the growth of any other civilized country. The bolshevism of Russia and the nationalism of China, whatever their

meaning may be, have undoubtedly a definite meaning in the evolution of these two nations; I am not competent to express an opinion on this subject, but I feel confident that these two nations, covering, as they do, territories similar to these of the United States, both in size and natural resources, must adopt the American motto: Consolidation of the Union. When they do, the American machine will confer all the blessings upon them which it has conferred upon our nation, provided, of course, that its operation is guided by an idealism similar to that of Washington and of Lincoln.

III

ROMANCE OF THE TELEPHONE

THE service of the telephone in the consolidation of our Union was an epoch-making service. No other country availed itself of the consolidating power of the telephone as much as this country did. No other country needed it as much. There is another epoch-making service which the telephone rendered to this nation. This service was the creation of a great American telephone industry, which in many respects serves to-day as a model to other big American industries. This second service of the telephone will be described now briefly. The description will, I hope, exhibit more fully the latent powers of this wonderful American machine.

The consolidation of the Union by the network of telephone and telegraph circuits which were gradually spread over the United States during the first thirty-year period after the Civil War was wonderfully advanced during the second thirty-year period. This is well described in a recent statement of the president of the American Telephone and Telegraph Company, which says:

"The telephone business has been so organized and developed here that to-day practically anybody, anywhere, can talk at any time of the day or night with anybody anywhere else—not only in the United States, but in Mexico, Cuba, Canada, and most of Europe."

With so marvellous a network of telephone circuits superimposed upon our extensive network of railroads, automobile roads, steamboat lines, and aeroplane routes, the United States

represent a compact unit of nearly a hundred and twenty millions of people; they are, in many ways, just as compact a unit as any European nation. In addition to this physical consolidation created by machines, particularly by the telephone, we have the same language, the same educational system, the same national aspirations in every nook and corner of our vast territory.

The rapid rise of a compact and homogeneous nation with so large a population, covering a vast territory in which are stored up treasures of great natural resources, is a unique event in the history of mankind. In such a nation one can expect unique economic developments which will puzzle the rest of the world. The following brief sketch of the history of the American telephone industry will illustrate one of these developments.

THE RISE OF ECONOMIC DEMOCRACY

Our ideal of political democracy, as described in Lincoln's Gettysburg speech, was destined to give birth to a peculiarly American ideal of economic democracy which is, broadly speaking, a corollary of Lincoln's ideal of political democracy. It demands that the wealth-producing activities of our nation should be for the benefit of all the people, and not for the benefit of single groups of people. Economic democracy interests our masses to-day even more than political democracy. This thought was perhaps in the mind of President Butler of Columbia University when in his last Christmas greeting he makes the following statement:

"The shift of the position of the centre of gravity of human interest has been from politics to economics, from considerations

which had to do with forms of government, with the establishment and protection of individual liberty, to considerations that have to do with the production, distribution, and consumption of wealth. We must bend every energy to make both defense of liberty and the production and just distribution of wealth the means of building the moral fibre of individuals."

This shifting of the centre of gravity of human interest from politics to economics has advanced in this country much further than anywhere else in the world; in no other country has the production of wealth with its many economic problems of distribution and consumption progressed so much and so rapidly as in this country. This was particularly true during the last thirty years, when this nation, thanks to the blessings which the consolidating power of machines had conferred upon it, was approaching its highest forms of consolidation. This was as it

ought to have been, because consolidation transformed this nation into a compact and homogeneous unit of a hundred and twenty millions of people

". . . ambitious to achieve, universally educated, free from class prejudice, and possessing unusual ability for organization, with a conception of government looking toward the well-being of all. . . ."

The words just quoted are the words of the president of the American Telephone and Telegraph Company. Nobody is better qualified to testify in this matter than he. His testimony is the testimony of the largest and most perfectly co-ordinated industrial organization in the world. Just think of it, an organization "employing," as he tells us, "four hundred and fifty thousand American men and women, operating physical properties representing an investment of four billions

of dollars which are owned by more than five hundred thousand stockholders." Here is an industry which is practically owned by the people of moderate means; many of them are in the employ of the industry. The millionaires do not possess sufficient capital to control an investment of four billions of dollars. But even if they had the control, it would not change the inevitable course of events in the evolution of the American telephone industry. This industry was destined to advance along paths which lead to industrial democracy, and it has arrived there. Its president, vice presidents, and other high administrative officers are men of moderate means; they are all highly trained scientific and administrative experts whose highest aim is excellence of service and whose highest ambition is professional achievement and distinction, and not personal

gain nor wealth. Their policy has created, as their president tells us,

". . . a type of management which recognizes that its responsibility is threefold —that in fact, if not in law, it is a trustee acting in the joint interest of owners, workers and customers."

Encouraged by this democratic spirit of his Company, he offers the opinion that ". . . a democratic and wide-spread prosperity is peculiarly an American ambition and an American accomplishment." These words assure us that the telephone industry is progressing rapidly toward the ideal of economic democracy, and that the other great American industries are following its leadership.

Our telephone industry was undoubtedly the first large American industry which blazed the way in the direction of economic democracy. This

was perfectly natural; it started as a large number of tiny local telephone corporations, most of them independent of each other, and each of them looking ahead to its own individual advancement. Such a state of things paralyzed progress in the telephone art. Mergers and consolidations were sorely needed, and dire necessity forced these tiny and numerous local corporations to merge in spite of the legislators, who dreaded the approach of a big telephone monopoly. An industrial organization extending to every part of our vast territory was the result of this merging process, resembling in a striking manner the result of the consolidation of the United States. It is obvious that in a great telephone industry, rising gradually out of the merging of numerous small corporations, the stockholders as well as the subsidiary operating companies were

spread over the whole of the United States. A co-operation between them was badly needed. American genius for co-operative organization proved equal to this great task; the final result was an industrial democracy. In no other country in the world did the telephone industry pass through the evolutionary stages similar to those through which it passed in the United States. Hence in no other country does this industry mean what it means here, nor does it influence the progress of the country's civilization as much as it does here.

This brief and rough sketch of the genesis of our great telephone industry suffices to show that this industry was destined to be guided by the democratic spirit which, as its president so clearly states, guides it to-day. Without this spirit the splendid co-operation between the numerous and widely sep-

arated parts of this industry would have been impossible. In other words, this wonderful organization which the whole world admires and whose policy of democratic management all our industries are gradually adopting could not exist to-day, except as an economic democracy.

Who can contemplate the great achievements of the industrial democracy inaugurated by our telephone industry, without being assured that it is a joyful message of an approaching civilization which will be more just and generous to the worker than any which the world has ever seen? Our telephone industry and the other large American industries encourage us in the belief that we are much nearer to the ideal of economic democracy than we are to Lincoln's ideal of political democracy. The first is developed by scientists and engineers, the second is

in the hands of politicians. Does not the last presidential election indicate that the people of the United States are drifting in the direction of the scientists and engineers and away from partisan politics? Employing President Butler's words one can say that the centre of gravity of popular interest in this country is shifting from politics to economics.

The tiny American machine, the telephone, crowned itself with glory by its wonderful service in the consolidation of our Union. An equally glorious achievement is its creation of a great industry which is developing so rapidly the new doctrine of economic democracy and exhibiting in practice its wonderful power. The world was greatly puzzled by this American machine when it was first exhibited at Philadelphia in 1876. Those who were devoid of vision considered it a

mere toy. But there were many prophets who predicted a brilliant future for it; there was not a single one among them who ever dreamed that this tiny machine would ever cover itself with the rare laurels which adorn its modest brow to-day. Its history reads like a romance, but, nevertheless, it is a record of actual events which occurred during the lifetime of many of us who are living to-day. The European critics of our machine civilization do not know the history of this wonderful American machine, nor do they understand the full meaning of the American industry which it created. How can they, when this American invention and the telephone industry which it created never meant in any country of Europe what they meant and still mean here? Government ownership in Europe smothered the latent powers of European telephony.

I cannot close this eulogy of the telephone and of the great industry which is its offspring without quoting the words of the chairman of the American Radio Corporation in his recent deposition before a committee of the United States Senate. He said:

"I pay this tribute, gentlemen, to the American Telephone and Telegraph Company not because I have any interest in it, direct or indirect; nor have any of the companies with which I am associated. . . .

"I say what I do about telephony under these circumstances because I am talking about communications, and because I wish to acknowledge publicly the great service which has been rendered."

These words describe my sentiments completely. I said what I did about telephony, because I wish to describe the romance of the telephone, and to acknowledge publicly the great national service which it has rendered.

No other American industry is so typically American as our telephone industry. None of them employ a larger number or a more abundant variety of machines than this industry; hence none of them represent better our American machine civilization. We are proud of our telephone industry, and of our machine civilization which this industry represents so well. Our European critics will never understand our civilization until they have mastered the present structure as well as the past history of our telephone industry.

ROMANCE OF THE VACUUM-TUBE OSCILLATOR

The first thirty-year period of what I called the age of electrical machines will always be remembered by the invention of the telephone, the most remarkable electrical machine of that

period. The succeeding thirty-year period will be remembered by the invention of an electrical machine which is in some respects even more remarkable than the telephone; it is the vacuum-tube oscillator, the backbone of the radio art of to-day. Without it radio broadcasting would be impossible, and radio broadcasting is the breath of life of our American radio industry. The phenomenal popularity of radio broadcasting has lifted the radio industry from its humble position of seven years ago to the exalted position of a major American industry of to-day. It has placed in the hands of the American people over seven million radio receiving sets, and its annual business has climbed up to seven hundred million dollars. No other machine in the history of the technical arts can boast of so great an achievement in so short a time as the vacuum-

tube oscillator. But no other new machine ever received the enthusiastic support from the research laboratories of our electrical industries which this machine and its accessory apparatus received.

Several of our big electrical industries, encouraged by high Federal authority, joined hands eleven years ago and formed a co-operative association, the Radio Corporation of America, for the purpose of developing the radio art which the vacuum-tube oscillator promised. The United States Navy gave it its blessing, believing firmly that it would give to the American radio art the world leadership in trans-oceanic radio communications. This was what our Navy needed, and this was the ambitious goal which the Radio Corporation of America set out to reach. It reached it in less than five years, thanks to the rapid development

of the vacuum-tube oscillator and of its accessory apparatus, and to the great popularity of radio broadcasting which this oscillator made possible.

Our world leadership in the art of trans-oceanic radio communications was recently challenged by Great Britain, when she merged the interests of her radio and cable companies. The British learned from stern experience that in trans-oceanic communications radio and cable must co-operate, if the best results are to be obtained. We should benefit from their experience and follow their example. We cannot meet the British challenge successfully without a merger of our radio and cable interests. These interests are willing, but our legislators hesitate. They are afraid of aiding in the creation of a new monopoly. This will probably delay the highest development of our trans-oceanic radio communications.

But he who understands the latent powers of the vacuum-tube oscillator and the trend of our civilization knows that this delay will be very brief.

Every epoch-making American invention, like the telephone and the vacuum-tube oscillator, is destined to perform an important mission in the service of the nation. The highest mission of the telephone was and still is the advancement of the consolidation of our Union. The growth of our nation always needed it, and that need overcame all obstacles. Legislative interference could not prevent the latent powers of the telephone from pushing the performance of its great mission to higher and higher levels of perfection until it finally convinced the people and the legislators that telephony is a natural monopoly. This monopoly gave us the leadership in the world of

the telephone art and, as already pointed out above, it has proved to be one of the greatest blessings which applied science ever conferred upon this nation.

The history of the telephone shows, therefore, that the latent powers of an epoch-making machine cannot be permanently smothered by the legislator's dread of monopolies. These powers will triumph sooner or later. The latent powers of the vacuum-tube oscillator for trans-oceanic communications will not and cannot be smothered very long. If the fullest development of these powers demands a merger of our radio and cable interests then the merger will surely come, in spite of the possibility that this might create a new monopoly. One of the great services which the telephone has rendered to this nation is its demonstration that an industrial monopoly,

wisely administered, can be a national blessing.

Electrical communications with our neighbors in South America and Eastern Asia, in Europe, Africa, and Australia demand that our radio and cable interests unite their best efforts in the development of trans-oceanic communications. Just as the telephone gave us a consolidation of our Union such as was never dreamed of sixty years ago, so the radio art created by the vacuum-tube oscillator, if supported by the resources of our cable companies, will give us a similar consolidation with our trans-continental and trans-oceanic neighbors. One need not be an economist of high acumen, in order to see that such a consolidation of this nation with our trans-oceanic neighbors, and particularly with South America and Eastern Asia, is greatly needed; that it is, in fact,

one of our national problems, the solution of which has been brought within our reach by the vacuum-tube oscillator. Radio broadcasting within our own borders is certainly a great achievement of this oscillator; the consolidation with our trans-continental and trans-oceanic neighbors will be just as great. Nothing short of broadcasting to all the nations of the earth is the ultimate goal of the radio art which was created by the invention and development of the vacuum-tube oscillator.

The following bit of history should be mentioned now: Benjamin Franklin devoted much study to the motion of electricity in Leyden-jar discharges, and he inferred from them that lightning is a motion of electricity. That was in the childhood days of the electrical science, when the earliest dawn of the slowly approaching day of electrical machines first appeared. About

a hundred years later Professor Joseph Henry of Princeton College demonstrated that the motion of electricity in Leyden-jar discharges is a rapidly oscillating motion. The Leyden jar is the first machine employed in the production of rapidly oscillating motions of electricity, and its earliest history, which is, in fact, the earliest history of radio, will always be attached to the two American names, Franklin and Henry. It was employed a little over forty years ago by Hertz in his classical experiments which demonstrated the correctness of Maxwell's electro-magnetic theory. This theory prophesied, that every rapidly oscillating electrical motion in a conductor, like that of the circuit of a suitable Leyden jar, will send through free space waves of electrical energy which are propagated just like the waves of light, and this prophecy Hertz verified. Marconi's

earliest antenna was a special form of a Leyden-jar circuit of the Hertzian type when, thirty-four years ago, he demonstrated that the electrical wave pulses, radiated from such an antenna into free space, indicated clearly the practicability of wireless telegraphy. From that day on a generator of sustained electrical oscillations was the highest aim of radio inventors and engineers. It was recognized that such a generator would be an ideal transmitter in wireless telegraphy. It was reserved for American science and engineering to discover and develop such a generator, the vacuum-tube oscillator, the crowning product of radio research.

Marconi, stimulated by Hertz, gave us wireless telegraphy. American invention and engineering, stimulated by the wireless, gave us the radio art by the invention and development of the

vacuum-tube oscillator. The radio of to-day is an American creation. It is a product of the American machine civilization. Is that achievement a utilitarian materialism? Let our European critics answer this question.

The two American machines, the telephone and the vacuum-tube oscillator, the two inseparable twins in the radio art, have been shaping and they will continue to shape our American civilization. They promise to shape the other civilizations of the world in a similar way. Their achievements so far justify the comforting hope that their latent powers will consolidate the nations of the world, so that some day they will be, like the United States, one compact unit, worshipping the same ideals, and all yearning for peace on earth and good will among men. If the American Machine Civilization, guided by the latent powers of its

heavenly twins, the telephone and the vacuum-tube oscillator, succeeds in paving the way to that supreme achievement, and many feel confident that it will succeed, it can well afford to say to its European critics who accuse it of materialism: Father, forgive them, for they know not what they are doing.

It looks like an act of providence that the telephone was born when the consolidation of our Union needed it most; the vacuum-tube oscillator arrived in time to lend its aid in the consolidation of this nation with the other nations of the world. Many an enthusiast believes that these two machines are messengers sent from heaven to aid in the guidance of the destiny of this nation, and of the whole world. This enthusiasm is not surprising. Just think of what a vacuum-tube oscillator at the sending end, and a loud-speaking

telephone at the receiving end of a radio circuit can do! Ask the lonely herdsman in the prairies of the West, or the ranchers in the Arizona and New Mexico deserts, and they will tell you. Ask the audience of millions of people who are listening to President Hoover's messages, and they will teach you. Ask the man in the Australian jungle what he thinks of the magic of these two American machines when in his hut in the solitary wilderness he listens to Fritz Kreisler's tuneful performance somewhere in Europe or America. Ask Rear Admiral Byrd what he thinks of the heavenly twins when his radio receiving set brings him our affectionate greetings, and he in return makes his vacuum-tube oscillator tell us the story of his thrilling daily experiences in the Antarctic. These achievements encourage the hope that we shall soon live in a new

world, which is free from barbarous notions handed down to us from past generations. There will be no place for barbarism, like war, in a world in which the two American machines, the telephone and the vacuum-tube oscillator, are afforded every opportunity to develop their latent powers for the enlightenment of the world.

Here are two machines which the American machine civilization has produced, and thus laid the foundation of the radio art, the most subtle and refined of all the technical arts ever conceived by the human mind. No trace of materialism can be detected in their history. On the contrary, their achievements represent them as messengers from heaven sent to earth to rid the world of barbarous notions and raise it to a higher level of civilization. The European critics of our Machine Civilization will do well to credit it

with this marvellous contribution for the good of mankind.

ROMANCE OF THE GAS MOTORS

The gas engine never enjoyed the popularity of its older companion, the steam engine, until it was called upon to supply the moving power for two new and epoch-making machines; I mean the automobile and the aeroplane, called here gas motors for brevity. Although of comparatively recent date these two machines have already produced wonderful changes in modern civilization.

The aeroplane remained a fond hope, only, until Wright brothers made one, stepped into it and flew. This achievement proclaimed them the real inventors of it, and their invention dates back to a little less than thirty years ago. The automobile began to attract universal attention just

about that time. Before that time it was reserved for the amusement of the sporting rich. The people of ordinary means could not afford it, and it looked as if they were nursing a grudge against those who could. The machine threatened to create a class distinction and the American spirit of democracy rebelled against it. Hence the lack of popularity of the automobile among the masses during its early history.

The rapid development and the brilliant achievements of the automobile and of the aeroplane will always be considered the greatest triumph of the gas engine. An engineer was asked recently, what machine he considered to have produced the most revolutionary changes in our daily life. He answered promptly: "The gas engine." He was, strange to say, an electrical and not a mechanical engineer. Although familiar with electrical power transmis-

sion, electrical lighting, and telephony, he considered the achievements of these electrical arts as less intimately connected with our daily life than the achievements of the gas engine. He had, of course, the automobile in mind. Every New Yorker, who on some pleasant Sunday afternoon takes out his automobile for a pleasure drive to Long Island, or along the Hudson River to Bear Mountain bridge, or across the ferries to New Jersey, will be inclined to agree with that engineer. The roads are blocked for many miles, and the endless string of automobiles taking their owners for a Sunday afternoon outing makes one believe that every family in New York has an automobile, and that they are all out for a pleasure drive. The Sunday afternoon swarms of automobiles on all state highways in the country districts make it appear that every farmer, every lit-

tle country merchant, and every industrial and rural worker has an automobile. Perhaps this is not very far from the truth, considering that over twenty-five million automobiles are in the hands of the American people. This is certainly a most striking exhibition of our economic democracy.

The unparalleled popularity of the automobile is responsible for the expenditure of many hundreds of millions of dollars annually for the construction of our magnificent concrete roads which are springing up everywhere. License fees and gasoline tax take care of that. One can motor from New York to Chicago, or to New Orleans, or even to San Francisco and Los Angeles and be moving over smooth concrete roads a very considerable part of the distance. Before many years have passed all our state roads will be concrete roads, and motoring from the

Atlantic to the Pacific coast will be a comparatively easy matter. Not a few people do it now, and very many indulge in numerous automobile trips which take them through many States of this Union. They have learned to know them almost as well as they know their own State.

Every State and every town welcomes the automobile tourist. There are no detentions of any kind on the State lines; in fact, one often passes from one State into another without knowing that he has crossed the State line. How different all this is from the annoyances which an automobile tourist experiences in Europe, whenever he crosses the frontier line between two neighboring nations; and he may cross several of them on the same day. I mention this for the benefit of our European critics. We not only have no economic or any other kind of bar-

riers between the States, but, on the contrary, ever since Washington's memorable words, "Consolidation of the Union," were addressed to this nation we always endeavored to create strong centripetal forces which will bring the peoples of our States closer to each other. The automobiles, the concrete roads, and the absence of barriers between the States occupy a prominent place among these centripetal forces. They have advanced the consolidation of our Union along the lines not easily reached by our railroads and waterways.

An automobile trip of two hundred and fifty miles a day is not a strenuous effort for an automobile moving over smooth concrete roads, and it is certainly a most exhilarating enjoyment. A trip of a few days offers many opportunities to call on old friends in the several States and make new ones. Per-

sonal friendships cementing the people of one State to that of another are certainly very effective consolidators of our Union. These friendships give one the joyful feeling that our Union is not only a compact political and economic unit, but that it is also a congenial association of friends. To aid in spreading this feeling throughout our nation is a higher mission of the automobile; to aid in creating that friendship between ourselves and our neighbors beyond the boundary-lines of the United States is an exalted mission of the aeroplane. Lindbergh's plane, carrying his honey-hearted smile, made many friends for us in Europe and in Central and South America. He was a true ambassador of our good-will to these countries and he was most enthusiastically received there as such.

To speak of an aeroplane as a carrier of messages of good-will to our

neighbors beyond our boundary-lines will sound strange to many good people of London and Paris who still remember the horrifying sound of enemy's aeroplane motors above their sleepless heads. But that horror was not the fault of the aeroplane nor of the gentle brothers of Dayton, Ohio, who invented it; it was the fault of the savage souls which transformed it into an engine of war. It was the fault of the savage civilization which tolerates war and permits the existence of international injustice and bitter hatreds which lead to war. Our machine civilization pleads "Not guilty" of the aeroplane horrors. When the World War broke out Europe had hundreds of aeroplanes fully equipped to serve as engines of war. The United States, the native land of the aeroplane, had none. When we entered the war we still had none suitable for service as engines of war, and

we practically had none on the Western front when the armistice ended the war. Our American machine civilization had to learn from Europe, the proud home of modern culture, how to transform the American aeroplane, a machine of peace, into a European engine of war. And yet our European critics condemn our machine civilization, because, they say, it neglects the spiritual side of human life!

The telephone, the telegraph, the vacuum-tube oscillator, the aeroplane, and the automobile, will certainly bring the peoples of the world closer to each other and establish between them bonds of friendship, just as they are establishing them between the peoples of our States. That is the highest mission of these machines. We do not yet appreciate fully their latent powers for carrying this mission to every nook and corner of the

world. The world needs the art of cultivating friendship between nations. It is the noblest of all the fine arts; its spirit is the spirit of Christ's commandment: Love thy neighbor as thyself. No civilization which neglects it can endure.

Our machine civilization rendered precious service when it gave to the world the telephone, the telegraph, the vacuum-tube oscillator, and the aeroplane, to aid the world in the art of cultivating international friendships. No other art can better serve the cause of peace and harmony between nations. One cannot contemplate the highest mission of these American machines without recalling to mind the following words in Washington's Farewell Address:

"Observe good faith and justice toward all Nations; cultivate peace and harmony with all. . . ."

These words breathe the true Washingtonian spirit which was the guiding light of our nation ever since Washington sent his Farewell Address to his "Friends and Fellow-Citizens." The Kellogg pact, President Hoover's conferences with Premier MacDonald, and our friendly endeavors at the recent naval conference in London, were all guided by that spirit. It is to-day the spirit of our American machine civilization. It invented and developed machines whose highest mission is to advance the art which Washington loved, the art of cultivating peace and harmony with all Nations. I cannot close this brief story of the services which the machine has rendered to the consolidation of our Union without referring to the following historical incident.

THE GREAT AMERICAN EXPERIMENT

At a public dinner in the city of Washington, commemorating in 1832 the hundredth anniversary of Washington's birth, Daniel Webster was the orator of the occasion. I quote the following passages from his memorable oration:

"It was the extraordinary fortune of Washington that, having been intrusted in revolutionary times with the supreme military command, and having fulfilled that trust with equal renown for wisdom and for valor, he should be placed at the head of the first government in which an attempt was to be made on a large scale to rear the fabric of social order on the basis of a written constitution, and of a pure representative principle. A government was to be established without a throne, without an aristocracy, without castes, orders, or privileges; and this government, instead of being a democracy existing and acting within the walls of a single city, was to be extended over a vast country of different climates, interests, and habits, and of vari-

ous communions of our common Christian faith. The *experiment* certainly was entirely new. . . ."

". . . the whole world was and is interested in the result of this *experiment*.

"Gentlemen, for the earth which we inhabit, and the whole circle of the sun, for all the unborn races of mankind, we seem to hold in our hands, for their weal or woe, the fate of this *experiment*.

"Finally, gentlemen, there was in the breast of Washington one sentiment so deeply felt, so constantly uppermost, that no proper occasion escaped without its utterance. From the letter which he signed in behalf of the Convention when the Constitution was sent out to the people, to the moment when he put his hand to that last paper in which he addressed his countrymen, the Union,—the Union was the great object of his thoughts. . . ."

The first three passages show that "the edifice of constitutional American liberty," as Webster called the American structure of government, was still an *experiment* the result of which was not yet beyond all doubt

when he delivered that memorable oration. The word *experiment* which Webster used so frequently on that occasion, and which I have put in italics, was undoubtedly suggested by the following words in Washington's Farewell Address:

". . . Is there a doubt, whether a common government can embrace so large a sphere? Let experience solve it. . . . We are authorized to hope, that a proper organization of the whole, with the auxiliary agency of governments for the respective subdivisions, will afford a happy issue to the *experiment*. It is well worth a fair and full *experiment*."

Webster, the disciple of Washington and teacher of Lincoln, referred to the most anxious thoughts of his master and of his pupil, when, in the passage just quoted, he mentioned the two historical documents in which his master pleaded fervently for the preservation and consolidation of the

Union. The preservation of the Union was also the ever-recurring theme of Webster's powerful oratory.

To Washington, in 1796, and to Webster, in 1832, the Union was an experiment. Even in 1863, when Lincoln delivered his Gettysburg speech, the fate of this great national experiment was acknowledged by him to be in the balance.

Those were the anxious thoughts of the three greatest Americans. The success of the great experiment, the Union cemented by constitutional American liberty, was the most precious object of these thoughts; it became the most precious object of the thoughts of every true American. One cannot help believing that this object was also uppermost in the minds of American scientists, engineers, and inventors for many years, otherwise one cannot account for the remarkable

fact that the telegraph, the telephone, the vacuum-tube oscillator, and the aeroplane are all American inventions and all of them most efficient consolidators of our Union.

In two years from now this nation will celebrate the two hundredth anniversary of Washington's birth. Will the orator on that occasion call our Union, as Webster called it a hundred years earlier, an experiment in the "result of which the whole world is interested"? Or will he, using Webster's language, call it "the edifice of constitutional American liberty" which is no longer in a shaky experimental stage as it was in the days of Washington, Webster, and Lincoln—but that it is as firm as the Rock of Gibraltar? Yes, he will say that, and he will assure the watchful world that the great American experiment is finished, and that the result, stated in

Webster's eloquent language, "is a more glorious edifice than Greece or Rome ever saw, the edifice of constitutional American liberty." Washington and the great patriots of his time designed this edifice, Lincoln preserved it during the greatest political cataclysm in American history, and the American machines consolidated its parts and gave it a beauty of form which is in perfect harmony with the spirit of its designers. One cannot understand the American machine civilization without understanding the spirit of these designers and the work of the American machines which aided the builders of the edifice. The designers, the builders, and the machines employed by them are the inseparable parts of the American machine civilization.

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